more compressed fruit and carpel, prominent dorsal and intermediate ribs and winged lateral ones, etc., etc.

Enantiophylla Heydeana, n. sp. Plate V.—From 12 to 15^{dm} high and much branched: leaves large, 3-ternate or 2-ternate-pinnate, or the upper ones simply ternate or pinnate; leaflets lanceolate, acuminate, 5 to 7.5^{cm} long, glabrous above, paler and minutely scabrous on the veins, sharply and finely serrate; petiole broad and inflated: inflorescence large; upper branches verticillate, terminated by an umbel; peduncle 3 to 7.5^{cm} long; rays 12 to 30^{mm} long; pedicels 6 to 8^{mm} long: bracts of involucre and involucel several, linear, and with scarious margins: fruit 10^{mm} long; wings of lateral ribs about as broad as body; the dorsal ribs sharp and equal.—Collected by Rosalió Gómez, in fruit, at Santiago, Depart. Zacatepequez, at an altitude of 6,500^{ft}, 1891; and by Heyde, in flower, along the banks of the Rio Esclavo (where it is said to be common) near Santa Rosa, Depart. Santa Rosa, at an altitude of 3,000^{ft}, May, 1892. Distributed by John Donnell Smith under nos. 788 and 3,352 respectively.

CORIANDRUM SATIVUM L.—Introduced. Santa Rosa, Dept. Santa Rosa, at an altitude of 3,000^{ft}, July, 1892, no. 3,347. Collected by Heyde and Lux.

DAUCUS MONTANUS Willd.—San Miguel Uspantán, Dept. Quiché, at an altitude of 6,000 to 12,000^{ft}, April, 1892, no. 3,355. Collected by Heyde & Lux.

Bloomington, Ind., and Washington, D. C.

Influence of anæsthetics on plant transpiration.[1]

ALBERT SCHNEIDER.

WITH PLATE VI.

I. Historical and critical.

Recently Jumelle conducted some very interesting experiments on the influence of anæsthetics on plant transpiration. He made an extensive study of plant chemism, chlorophyll-function and transpiration, which led him to give his final report on plant anæsthesia in the July number, 1891, of the

[1] The researches described in this paper were carried on in the laboratories of physiological botany of the University of Minnesota at Minneapolis.

Revue Générale de Botanique. A very brief summary of his conclusions may be stated as follows:

1. The luminous rays of the sun are partially utilized in assisting assimilation and partially in increasing "chlorophyllian transpiration."

2. Part of the luminous rays are absorbed by the chlorophyll bodies and converted into heat, increasing vapor tension and thus aiding transpiration.

3. The same dose of sulphuric ether acts differently on plant transpiration in the light and the dark. In light transpiration is increased but in the dark retarded.

4. Augmentation in light of transpiration of the anæsthetized plant is due to the influence of the sulphuric ether on the chlorophyll bodies

5. The cause of retardation in the dark is not definitely explained.

6. Ether retards assimilation but increases chlorophyllian transpiration (in the light).

7. Ether partially arrests assimilation and the luminous rays no longer used in the assimilating function aid the chlorophyllian transpiration.

8. The same results are reached when assimilation is retarded by any means.

As will be seen from these conclusions, Jumelle adheres to the chemical theory of chlorophyllian transpiration as do also Wiesner and others. Pringsheim, Kohl, and others maintain that the influence of chlorophyll is purely mechanical, acting as a sort of a shade to protect the plastid from certain rays of sunlight. It is a well known fact that plants transpire, though devoid of chlorophyll, as in etiolated plants. The question as to the correct theory of plant transpiration need not be further discussed here. I simply wish to show how Jumelle came to what I think are erroneous conclusions. Jumelle has lately been carrying on a controversy with Verschaffelt who maintains that ether increases transpiration in the dark as well as in the light. This Jumelle has attempted to disprove in his final paper on anæsthetized plants.

By way of criticism it must be pointed out that, in the first place, Jumelle as well as Verschaffelt used only portions of plants in their experiments and hence their conclusions are of little practical value. In the second place they very possibly confounded *evaporation* with *transpiration* as I shall attempt

to show. It is well known that dead plant tissue loses water vapor much more rapidly than living tissue. There can be no transpiration in dead tisue; it is evaporation, and that is a distinctively mechanical process. Transpiration takes place in living tissues only and is dependent upon protoplasmic action. Anything that reduces protoplasmic activity will therefore reduce transpiration.

II. Experiments on protoplasmic movements.

It has been known for some time that ether reduces the activity of animal protoplasm. Since all forms of protoplasm are supposed to be essentially alike it is to be expected that ether will have a similar effect upon vegetable protoplasm. For the purpose of studying the effects of ether vapor on vegetable protoplasm I used cross sections of the leaf, bearing hair cells, of *Primula sinensis*, *Petunia violacea*, and *Lycopersicum esculentum*. These sections were placed in a hanging drop of water without a cover glass, with a suitable arrangement to expose the preparation to the ether vapor at any desired moment. Only a very short period (2 or 3 seconds) was sufficient to cause the protoplasm to collect in spheroidal masses which after a shorter or longer period returned to the normal condition. The following are some of the results obtained.

Conditions of light, temperature, and moisture were constant in all the experiments.

1. *Primula sinensis.*

Numbers indicate time, in seconds, required for a certain protoplasmic granule to move 10 μ.

First experiment.

Normal: 5, 4, 6, 5, 4, 5, 5, 4, 6, 5, 5, 4, 5, etc.
After momentary exposure to ether vapor, 4, 5, 5, 6, 6, 7, 6, 7, 7, 8, 8, 9, 9, 10, 10, 10.
Remained stationary at about 10 then returned to normal: 10, 9, 10, 9, 8, 8, 7, 7, 7, 6, 5, 5.

Second experiment; fresh sections.

Normal; 5, 6, 7, 5, 6, 5, 6, 5, 5, 6, 6, 5, 6, 6, 5, etc.
Exposed to ether vapor for 2 seconds; 6, 7, 7, 8, 9, 11, 11, 13, 14, 14, 15, 14, 14.
Remained stationary at about 14 then returned to normal: 14, 14, 13, 13, 12, etc.

2. *Petunia violacea.*

First experiment.

Normal: 6, 5, 5, 6, 6, 5, 5, 5, 6, 5, 6, 5, 5, etc.
Exposed to ether vapor for 4 seconds: 7, 8, 7, 8, 9, 10, 11, 11, 14, 15, 18, 19, 22, 40, 50, etc., until all motion permanently ceased.

Second experiment; fresh sections.

Normal: 5, 6, 5, 6, 5, 5, 6, 5, 6, 5, etc.
Momentary exposure to ether vapor: 5, 5, 6, 7, 7, 7, 8, 8, 9, 9, 8, 9, 8, 9, 8, 7, 7, 7, 6, 6, 5, 5.

Third experiment; fresh sections.

Normal: 5, 6, 7, 6, 6, 5, 5, 6, 6, 7, 6, 5, 6, etc.
Exposed to the ether vapor for one or two seconds: 5, 6, 6, 6, 7, 7, 7, 6, 7, 7, 8, 8, 9, 11, 12, 14, 15, 16, 16.
Remained stationary at 16 then returned to normal.

3. *Lycopersicum esculentum.*

Normal: 4, 5, 4, 5, 5, 4, 5, 5, 4, 5, 5, etc.
Momentary exposure to ether vapor: 4, 5, 6, 6, 7, 8, 10, 12, 14, 14, 15, 16, 16, 17, 17, 16, 17.
Then returned to normal.

From these experiments it will be seen that ether vapor reduced protoplasmic action, temporarily when exposed for a short time and permanently when exposed for a longer time. I might mention incidentally that ether vapor had no perceptible effect upon the position, size, or shape of the chlorophyll bodies.

III. Experiments on transpiration of entire plants.

Having noted the effect of ether vapor upon protoplasmic activity and believing that transpiration depends on protoplasmic activities, we may next proceed to the transpiration experiments proper. As already mentioned the experiments of Jumelle, and likewise those of Verschaffelt and Lommen, are really of little practical value because these investigators did not use the entire plant, root and all. In the following experiments I have employed a modified and improved Kohl transpiration apparatus which permits the use of the entire plant.[2]

Owing to the fact that this apparatus gives very delicate results and hence is easily influenced by slight changes of environment the following precautions must be observed in its use.

1. There must be no air bubbles in any part of tubes *b*, *h*, and *g*.[2]

[2] See plate VI and explanation.

2. The capillary tube, *h*, especially must be free from air-bubbles and other impurities.

3. All fittings to tube *b* must be air tight.

4. The tube *b* must be entirely filled with water.

5. The water used should be boiled to remove air.

6. The temperature of air and water must be stationary before observations are made.

7. Nothing must be placed in *b* that will generate gases, as culture fluids, etc.

8. The same plant must not be retained in tube *b* for more than 12 hours.

9. The water in tube *b* must be changed every time the plant is changed.

These precautions may assist in preventing faulty experimenting on the part of those who may not as yet have used a similar apparatus.

From a series of experiments I found that the daily period of maximum transpiration corresponds to the daily period of maximum growth (one to four o'clock P. M.). This seems to be additional evidence that transpiration depends upon assimilation.

I. RELATION OF LIGHT TO EFFECT OF ANÆSTHETICS.

The plant used in the following series of experiments was *Solanum tuberosum*. In all cases the plant was covered by the bell jar and dry air forced through by means of a pair of foot bellows. The air was dried by means of sulphuric acid and chloride of calcium. Of course the entire plant was used, root and all, care being taken not to mutilate the fine rootlets more than was unavoidable. No observations were made until the temperature of the air and water was nearly constant.

1. *Solanum tuberosum*, small plant, seven leaves, three small, developing tubers; in diffused light.

Time	Tem. of water °C.	Tem. of air °C.	Normal or Anaest.	Time in seconds required to evaporate 5min of water column.	Average time.	Progress.
3:30	21½°	22⅔°	Normal	7, 7, 8, 7, 6, 8, 7, 7, 8, 7, 6, 7, 8, 7	7.2	Ether introduced
3:34	21⅓°	22½°	Ether.	7, 8, 7, 7, 6, 7, 8, 9, 9, 8, 9, 9, 10, 9		
3:50	21½°	22½°	Normal	10, 11, 11, 11, 12, 12, 12, 13, 13	7.2–11.4	Ether removed.
4:20	21°	20½°	Normal	12, 11, 12, 11, 10, 8, 7, 8, 7, 7, 8, 7	11 4–7.2	
4:24	21°	20½°	Aml nit	7, 7, 8, 7, 7, 8, 8, 7, 7, 7, 8, 7, 8, 7	7.3	Amyl nit. inhaled
4:32	21°	20½°	Aml nit	7, 7, 8, 7, 7, 8, 7, 8, 8, 8, 7, 8, 8,	7.5	After 5 min. amyl nit. removed.
4:45	20 5-6°	20¼°	Normal	12, 11, 12, 13, 13, 12 14, 13.....	12.37	
				13, 13, 12, 12, 13, etc. to normal.	12–7.5	End.

2. *Solanum tuberosum*, small plant, eight leaves, no tubers; in diffused light.

Time	Tem. of water °C.	Tem. of air °C.	Normal or Anaest.	Time in seconds required to evaporate 5mm of water column.	Average time.	Progress.
11	21⅔°	24.5°	Normal	10, 11, 11, 10, 12, 11, 10, 12, 11	10.8	Ether introduced
11:14	21⅔°	24.5°	Ether.	11, 11, 10, 11, 11, 12, 11, 12, 12	11+	After 10 minutes
11:18	21¾°	24.5°	Ether.	16, 17, 17, 16, 17, 17, 16, 18, 17	16 7-9	ether removed.
11:23	21¾°	24.5°	Normal	16, 16, 14, 13, 13, 12, 11, 10, 11	16–10	End.
Ether introduced and left until 2 P. M.						
2:00	23°	24.9°	Ether.	75, 73, 75, 72, 70, 73, 75	73	Ether removed
2:15	23°	24.9°	Normal	75, 70, 73, 71, 74, 73, 72, 70.....	72	after 10 min.
2:30	23°	24.9°	Normal	36, 35, 36, 32, 35, 34, 34.....	32.5	End.

It will be seen that the plant did not return to its normal transpiration after it had been exposed to ether vapor from 11:30 A. M. to 2:00 P. M. The ether had partially killed the plant as the subsequent drying up and shriveling of the tips and margins of some of the leaves served to indicate.

3. *Solanum tuberosum*, small plant, six leaves, no tubers; in direct sunlight.

Time	Tem. of water, °C.	Tem. of air, °C.	Normal or anæsthet.	Time in seconds required to evaporate 5mm of water column.	Average Time.	Progress.
2:30	22¼°	30°	Norm'l	5, 6, 5, 6, 5, 5, 6, 5, 6, 6, 5, 5.....	6.1	Ether introduced
2:34	22¼°	30°	Ether ..	6, 5, 6, 6, 6, 7, 7, 8, 8, 9. 8, 9,9, 9	6–9	Ether removed.
2:36	22¼°	30°	Norm'l	8, 8, 7, 6, 6, 5, 6, 5, 5, 6, 6, 5.....	9–6	Chlorof'm int'ced
2:38	22¼°	30°	Chl'frm	5, 5, 6, 5, 6, 6, 5, 6, 7, 6, 7,7, 8, 9	6–9—	Chlorof'm rem'vd
2:40	22¼°	30°	Norm'l	8, 8, 7, 7, 6, 6, 5, 6, 5, 5, 6, 5.....	9–6—	

These experiments seem to show conclusively that a plant exposed to the vapor of ether, amyl nitrite or chloroform, will have its transpiration very materially diminished. I took no special notice of the amount of anæsthetic used because I soon found that the effect was the same independent of the quantity used. Of course a small quantity required a longer time to produce given effects. Ether and chloroform I poured in any vessel from which it could evaporate. Amyl nitrite was used by putting two or three drops on a piece of cotton under the bell jar. It will be remembered that during all these experiments a current of dry air was passed through the bell jar, carrying with it most of the vapor; still there was sufficient left to produce the given results. Exposing the plant to amyl nitrite vapor for ten or fifteen minutes was suf-

ficient to kill the greater portion of it. It could withstand a much longer period of exposure to ether and chloroform vapors.

The following set of experiments, 4 to 6, relate to the influence of anæsthetics on plant transpiration when the plant is exposed to the various colors of the solar spectrum. I found it rather difficult to obtain pure colors. The colors I desired were red, yellow and green. Red and green I was able to obtain quite pure; but it was impossible for me to obtain yellow that did not also transmit red. The following is a list of substances with result of spectrum analyses. The thickness of the liquid was in all cases 13^{cm}.

Color.		Dye used.	Rays transmitted.
Red.	1	Eosine	From 65 to 75.
	2	Carmine	From 66 to 73.
	3	Fuchsine	From 68 to 75.
	4	Safranine	From 67 to 75.
	5	Magdala red	From 64 to 75.
Yellow.	1	Methyl orange	From 56 to 75.
	2	Gold orange	From 58 to 75.
	3	Orange	From 57 to 75.
	4	"Diamond dye" yellow	From 55 to 75.
Green.	1	Iodine green	From 45 to 56.
	2	Methyl green	From 45 to 57, and 72 to 75.
	3	Malachite green	From 46 to 56, and 72 to 75.
	4	Alcoholic chlorophyll solution	From 40 to 70.
	5	Copper chloride solution	From 40 to 70.
	6	Diamond dye yellow and blue	From 49 to 56.
Black.	1	Diamond dye black	Faint trace of all rays.
White.	1	Water	All rays of solar spectrum.

From these and various other colors which I examined, I selected fuchsine for red; "diamond dye" yellow, for yellow; a mixture of diamond dye yellow and blue, for green. Of these I made watery solutions in large double-walled bell-jars that could be placed over the plant on the apparatus in place of the ordinary bell-jar. Diamond dyes have an advantage in that the watery solutions do not form a sediment like many of the aniline dyes; they seem also to fade less quickly.

The transparency of colored liquids was made approximately alike, likewise was the thickness of the liquids in the various jars, and different parts of the same jar only approximate. Owing to the fact that a complete series of experiments must

be made with the same plant at one sitting, and since the period ot constant temperature and illumination during the day is short, I could not obtain such marked results as I could have obtained with longer periods of time. Also, the jars used were larger than the bell jars used in the second series of experiments; hence the effects of the anæsthetics did not appear as quickly, nor were the results so marked.

4. *Fuchsia* sp.?; small, five leaves, small roots, no flowers.

Time	Color.	Tem. of liq. °C	Tem. of air °C.	Tem. of water °C.	Anaest. or normal	Time in seconds required to evaporate 5 mm of water column.	Progress.
3.00	White	23.5	24	22	Normal	15, 16, 15, 16, 16, 15, 16, 16, 15,	Ether iutr'd.
3:04	dif. l.	23.5	24	22	Ether.	15, 16, 17, 15, 16, 15, 16, 16	After 6 minutes
3:10	"	23.5	24	22	Ether.	17, 18, 18, 18, 19, 18, 19, 19, 18	ether removed.
3:16	"	23.5	24	22	Normal	15, 16, 15, 15, 16, 16, 16, 15, 16	4 minutes.
3:19	Dark.	23	24	22+	Normal	16, 15, 15, 16, 15, 16, 16, 13, 16	Dark.
3:34	"	23	24	22.25	Normal	18, 18, 19, 18, 18, 19, 18, 18, 19	Aft. 15 m. et. in'd.
3:36	"	23	24	22.25	Ether.	20, 18, 18, 18, 19, 19, 18, 19	Aft. 5m. eth. rem.
3:42	"	23	24	22.25	Ether.	20, 21, 22, 21, 22, 21, 22	4 minutes.
3:49	"	23	24†	22.5	Ether.	18, 19, 18, 18, 19, 18, 19, 18, 18	End.

5. *Solanum tuberosum*, small plant, strong roots, no tubers.

Time	Color.	Tem. of liq. °C	Tem. of air °C.	Tem. of water °C.	Anaest. or normal	Time in seconds required to evaporate 5 mm of water column.	Progress.
11:20	White	21	22	20	Normal	10, 9, 10, 10, 9, 10, 9, 10, 10, 9	Ether intr'd.
11:22	dif. l.	21	22	20	Ether.	10, 9, 10, 10, 10, 9, 9, 10, 9, 10	After 8 minutes
11:30	"	21	22	20	Ether.	13, 12, 13, 13, 13, 12, 13, 12	ether removed.
11:35	"	21	22	20	Normal	10, 9, 10, 10, 9, 9, 10, 9, 9, 10, 10	Amyl nit. intr'd.
11:37	"	21	22	20+	Amyl n	10, 9, 10, 9, 10, 10, 10, 10, 9	After 3 minutes
11:41	"	21	22+	20	Amyl n	13, 13, 12, 13, 13, 13, 12, 13	amyl n. removed.
11:46	"	21	22	20	Normal	10, 9, 9, 10, 10, 10, 9, 10, 9, 9	
11:48	Dark.	21.5	22	20	Normal	10, 9, 10, 9, 10, 10, 9, 10, 10, 9	Dark.
12:02	"	21	22	20	Normal	12, 12, 12, 13, 12, 12, 13, 12	After 15 minutes
12:05	"	21	22	20	Amyl n	12, 12, 12, 13, 13, 12, 13, 12	amyl nit. intr'd.
12:11	"	21	22	20	Amyl n	14, 13, 13, 14, 14, 15, 14, 14	Af. 5 m. am'l rem.
12:16	"	21	22	20	Normal	12, 13, 12, 13, 13, 12, 13, 12	End.

These experiments show that ether as well as amyl nitrite reduces transpiration both in light and dark. I was very careful to have conditions of temperature and moisture the same in all cases. The above are only a few of a large number of similar results obtained. Variation in temperature, etc., caused me to repeat many of the experiments before I obtained satisfactory results.

The following is a series of experiments in which I used colored liquids, namely red and green, which were almost pure as seen from the table of spectrum analysis, and yellow which transmitted a trace of green, all the yellow, orange and red. To make the series complete I also repeated the experiments with white light and in darkness.

Without going into the discussion in regard to the influence of colored light on plant transpiration and assimilation, I will give the average results obtained from a series of experiments. The conditions of temperature and moisture were constant in all cases.

White light, diffused, required	54	seconds to evaporate	25	mm.	
Yellow " " "	60	" "	25	"	
Red " " "	62	" "	25	"	
Green " " "	64	" "	25	"	
Darkness "	72	" "	25	"	

The results obtained agree quite closely with those obtained by Déhérain, Engelmann and Kohl. Timiriaseff and Engelmann maintain that there is another position of maximum assimilation and transpiration in the blue; leaving that out of the question, I think that nearly all plant physiologists affirm that assimilation and hence transpiration is most active in the more luminous rays of the solar spectrum.

6. *Solanum tuberosum*, small plant, strong roots, no tubers.

Time	Color.	Tem. of liq. °C	Tem. of air °C.	Tem. of water °C.	Anaest. or normal	Time in seconds required to evaporate 5 mm of water column.	Progress.
11:30	White	21.5	22	21.5	Normal	11, 11, 11, 10, 11, 11, 10 10, 11, 11, 10	Ether introduced
11:34	dif. l.	21.5	22	21.5	Ether.	11. 11, 11, 12, 11, 10, 11, 11, 11, 12	After 10 min.
11:46	"	21.5	22	21.5	Ether.	13, 14, 13, 13, 14, 13, 14, 14 14	ether removed.
11:49	"	21.5	22	21.5	Normal	11, 11, 11, 10. 10, 11, 10, 11. 11, 11	Yellow l.
11:53	Yellow.	21	22	21.5	Normal	11, 11, 11, 10, 11, 11, 11, 11, 10. 11, 11	After 10 min.
12:04	"	21	22	21.5	Normal	12, 11, 12, 13, 12, 11, 12, 11, 13	ether introduced
12:10	"	21	22	21.5	Ether.	15, 14, 14, 15, 14, 14, 15, 14	Ether removed.
12:20	"	21	22	21.5	Normal	12, 11. 12, 12, 11, 12, 12, 11, 12	Red l.
12:25	Red.	21.5	22	21.75	Normal	12, 11, 12, 12, 11, 12, 11, 12, 13	After 10 min.
12:38	"	21.5	22	21.75	Normal	12, 13, 13, 12, 13, 13, 12, 13, 13	ether introduced
12:45	"	21.5	22	21.75	Ether.	15, 16, 16. 15. 15, 16, 16, 15, 16	Ether removed.
12:49	"	21.5	22.25	21.75	Normal	12, 13, 12, 13 13, 12, 13, 12	Green l.
12:52	Green.	21	22.25	21.75	Normal	12, 13, 12, 13. 13, 12, 13, 12, 13	After 15 min.
1:00	"	21	22.25	21.75	Normal	13, 13, 14, 13, 14, 14, 13, 12, 13	ether introduced
1:15	"	21	22.25	21.75	Ether.	16, 17, 16, 17, 16, 17, 16, 16, 17, 17	Ether removed.
1:25	"	21	22.25	22	Normal	13, 13, 14, 13, 13, 13, 12, 14, 13	Dark.
1:36	Dark.	21.5	22.5	22	Normal	13, 12, 13, 14, 13, 13, 12, 14, 13	After 30 min.
2:08	"	21.5	22.5	22	Normal	14. 15, 14, 14, 15, 14, 15, 14	ether introduced
2:20	"	21.5	22.5	22	Ether.	16, 17, 19, 18, 19, 17, 18, 18, 19	Ether removed.
2:26	"	21.5	22.5	22	Normal	14, 15, 14, 14, 13, 14, 14, 13, 14	End.

I experimented also with *Fuchsia* and *Geranium* with the results given above. These experiments indicate that the different colors of the spectrum do not affect the influence of ether vapor on plant transpiration.

II. RELATION OF ATMOSPHERIC MOISTURE TO INFLUENCE OF ANÆSTHETICS.

Atmospheric moisture does not affect the influence of ether vapor on transpiration, as the following experiments show. Kohl claims that transpiration is zero in the saturated atmos-

phere. I can not agree with him. Of course any one knows that in a saturated atmosphere moisture can not be given off as vapor. That would be a mechanical impossibility. It is also quite difficult to saturate an atmosphere evenly and completely with moisture. A bell-jar was not equally warm on all sides under the most favorable circumstances I could bring to bear upon it. At no time did transpiration approach zero after all the conditions of the experiment had been properly accounted for. In the following experiments the plant was exposed to diffuse sunlight.

1. *Solanum tuberosum;* small plant, strong roots.

Time	Tempe'ture		Condition of atmosphere.	Anæst. or normal	Time, in seconds, required to evaporate 5mm of water column.	Progress.
	Air °C.	Wat'r °C				
3:00	24.5	24°	Dry	Normal	7, 8, 7, 7, 8, 7, 7,8,7,8,7,7.8,7,7,7,8	In sat. atm'e
3:04	24.5	24°	Gradu'lly saturat'd	Normal	7,8,7.7 8,8.7,8,8,7,8,8,8,9.8,9,9.....	After 5 min.
3:10	24.5	24°	More saturated.....	Normal	10,10,11,10,11,11,11,12,11,12,13,13	After 10 min.
3:25	24.5	24°	More saturated.....	Normal	24, 24, 25, 26, 27, 29, 32, 35, 34.....	After 1 hour
4:30	24	23°	Practically satur'td	Normal	34, 36, 35, 36, 34, 32, 36, 37, 35.....	exp'd to ether
4:45	24	23°	Practically satur'td	Ether...	35, 38, 49, 64, 68, 78, 82, 84.....	Eth. remov'd
5:00	21—	22¾°	Practically satur'td	Normal	34, 35, 35, 36, 32, 35, 36, 34, 35.....	End.

2. *Fuchsia* sp. ?; small plant, strong roots, no flowers.

Time	Tem. air. °C	Tem. water °C	Condition of atmosphere.	Anæst. or normal	Time in seconds, required to evaporate 5mm of water column.	Progress.
10:15	21.5°	20°	Dry	Normal	9,8,8,9.8,9.8,8,9,9,8,9.8,9,8,9, 8.8	Plant moistened.
10:20	21.5	20	Part. sat'd.	Normal	14,14,15,14,15,15,16,16,18,17,18,19	After one hour
11:30	22	21.5	Prac. sat'd.	Normal	32, 31, 33. 31, 30, 33. 31, 32, 30,33	ether introduced.
11:40	22	21.5	Prac. sat'd.	Ether...	60, 66, 64, 67, 70, 68, 70, 74, 78.....	Removed.
12:00	22.5	22	Prac. sat'd.	Normal	30, 31, 32, 30, 32, 31, 32, 30, 31.....	Amyl n. introduced
12:15	22.5	22	Prac. sat'd.	Amyl n.	75, 64, 70, 76, 74, 70, 75, 76, 74, 71	Amyl n. removed.
12:30	22.5	22.5	Prac. sat'd.	Normal	33, 32, 34, 31, 32, 31, 34, 32, 33.....	End.

These experiments showed that moisture did not affect the influence of ether and amyl nitrite vapors on plant transpiration.

IV. Experiments on transpiration of leaflets.

Finally, to show the cause of Jumelle's apparently erroneous conclusions, I made a series of control experiments with *Solanum tuberosum* leaflets. There is no mechanical difficulty in performing these experiments, but they require close observation to avoid mistaken conclusions. The object of these experiments was to find the loss, in weight, of water in potato leaflets exposed to ether vapor in diffuse light and darkness. Jumelle states that he used the "branches" of various

plants in his experiments. Now it is in reality impossible to secure two branches from different plants (same species), or even the same plant, that are in all respects alike as to function and age, and which have been exposed to the same environments during life. To avoid these difficulties I observed the following precautions:

1. *Solanum tuberosum* leaflets were used.

2. Leaflets of the same leaf were used thus securing those of the same age, which had been exposed to the same external environments as nearly as possible.

3. The conditions of temperature and moisture were the same for all leaflets.

4. Only healthy looking leaflets were used.

5. Great care was observed in the handling of leaflets so as not to bruise them.

6. The petiole was cut straight across as near to the midrib as possible.

These leaflets were then weighed and placed on equal sized and seasoned pine blocks to keep them from the colder surface of the ground glass plate on which the blocks were placed. A well-fitting bell-jar was placed over each. Two leaflets were placed under normal bell-jars, two under dark bell-jars, blackened on inside with camphor soot. Two leaflets, one in the dark, the other in diffuse light were exposed to ether vapor evaporating from a flat dish, care being taken to have the same amount of ether in both cases in the same experiment. The following are the results:

1. Time of first exposure of leaflets, $1\frac{1}{2}$ hours.

Condition of light.	Anaesthet. or normal.	Weight in mg. before exposure.	Weight in mg. after exposure.	Loss in mg.	Per ct. loss
Diffused	Ether	126	117	9	7.14
Diffused	Normal	130	120	10	7.69
Dark	Ether	131	124	7	5.34
Dark	Normal	136	128	8	5.89

The same leaflets were again weighed after having been exposed for 6 hours.

Diffused	Ether	126	58	68	54
Diffused	Normal	130	87	43	33
Dark	Ether	131	71	60	36
Dark	Normal	136	96	40	29

During the first period of exposure the ether had reduced *transpiration* and hence reduced the loss of moisture.

In the second period of exposure the ether had killed all the protoplasm and hence *evaporation* took place and not *transpiration*, which accounts for the increased loss in weight.

2. Time of first exposure, $\frac{1}{2}$ hour.

Condition of light.	Anaesthetic or normal.	Weight in mg. before exposure.	Weight in mg. after exposure.	Loss in mg.	Loss per ct.
Diffused	Ether	51	50	1	1.9
Diffused	Normal	75	70	5	6.6

Conclusion: Ether retards transpiration in diffused light.

3. Time of exposure, $1\frac{1}{2}$ hours.

Diffused light.	Ether	236	223	13	5.5
Diffused light.	Normal	203	191	12	5.9

Conclusion: Ether retards transpiration in diffused light.

4. Time, $\frac{2}{3}$ hour.

Diffused light.	Ether	45	43	2	4.4
Diffused light.	Normal	57	54	3	5.2
Darkness	Ether	47	45	2	4.2
Darkness	Normal	32	30.5	1.5	4.7

Same leaflets weighed after 3 hours.

Diffused light.	Ether	45	34	11	26.6
Diffused light.	Normal	57	45	12	21
Darkness	Ether	47	35	12	25.5
Darkness	Normal	32	26	6	18.7

Conclusion: Ether retards transpiration in diffused light.

5. Time of exposure, $3\frac{1}{2}$ hours.

Diffused light.	Ether	90	67	23	25.4
Diffused light.	Normal	75	56	19	25.25
Dark	Ether	84	57	27	32
Dark	Normal	93	74	19	20.43

Conclusion: Owing to the long period of exposure the ether had stopped protoplasmic activities, and hence increased evaporation in both cases, but most in the dark, because leaflets in the dark were killed first.

6. Time of exposure 1 hour.

Diffused light.	Ether.....	64	57	7	10.9
Diffused light.	Normal.....	57	61	7	12.2
Dark.....	Ether.....	68	61	7	10.2
Dark.....	Normal.....	48	43	5	10.4

Conclusion: Ether retards *transpiration* in both light and dark.

V. Summary.

1. Ether retards protoplasmic action. Given in sufficient dose it kills protoplasm.

2. Ether retards transpiration by retarding assimilation.

3. Anything that retards assimilation will retard transpiration.

4. Increased loss of water vapor in the anæsthetized vegetable tissue is due to the fact that the anæsthetic has killed the plant tissue, thus allowing *evaporation* to take place, and not *transpiration*.

5. Ether retards transpiration under all conditions.

6. Transpiration is not essentially a chlorophyllian function.

7. Experiments in which the entire plant is not used are practically valueless.

8. Periods of maximum growth and maximum transpiration coincide.

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EXPLANATION OF PLATE VI.

a, stand made of well seasoned heavy oak. All the wood work is thoroughly soaked in hot paraffine to make it impervious to water.
b, a glass tube filled with water in which is placed the root of the plant experimented upon.
c, block of wood to hold *b* in its place.
d, rubber stopper fitting into *b*, with two openings, one for bent glass tube connected with *e* and the other for bent glass tube connected with *v*.
e, rubber tube connecting glass tube *g* with bent tube in *d*.
f, bent glass tube connected with capillary tube *h*.
g, glass tube closed at distal end. This is to regulate the position of the water column in *h*.
h, fine capillary tube connected with *f* and from which the observations are made.
i, heavy glass plate with ground surface.
j, glass tube passing through opening in *i* and wood work, connected with *z*.
j', rubber stopper in upper end of *b*, perforated to admit stem of plant experimented upon. An incision is made from surface to central perforation to admit plant.
k, bell jar.
l, rubber stopper, with two openings.
m, thermometer to register temperature of atmosphere in *k*.
n, bent glass tube to give exit to atmosphere.
o, sulphuric acid bottle to dry atmosphere before it is passed through *k*.
p, calcium chloride tube to assist in drying air.
q, rubber tube connected with *o* and an aspirator, hand- or foot-bellows.
r, small vessel containing water to be taken up by *h* when no observations are made.
s, metric scale on which to observe the rate of movement of water column in *h* while transpiration is going on.
t, an ordinary Mælzel metronome regulated to beat seconds to assist in making observations.
u, clamps to hold block *c* firmly in place.
v, small rubber tube to connect *f* with *h*.
w, perforated stoppers to hold a small thermometer in place. Above upper stopper should be placed a little cotton to act as a fitter to prevent sand, dirt, etc., from getting into *h*.
x, clamps to hold *p* in place.
y, rubber tube connecting *o* with *p*.
z, rubber tube connecting *p* with *j*.

Root in tube *b* is to be protected against direct sunlight and sudden changes of temperature by means of a black silk cloth and heavy pasteboard shields. Slight changes of temperature have but little effect on water because its coefficient of expansion is comparatively low. Bubbles of gas, however small, are very susceptible to changes of temperature, and make their presence known by the fluctuations of the water column in tube *h*.